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Publication date:
2016

Document Version
Peer reviewed version

Citation (APA):
Wu, K., Schmidt, M. S., Rindzevicius, T., Thilsted, A. H., & Boisen, A. (2016). *Macroscale SERS Uniformity and Reproducibility Using Densely Clustered Nanopillars*. Abstract from 43rd Annual North American Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies, Minneapolis, Minnesota, United States.

Macroscale SERS Uniformity and Reproducibility Using Densely Clustered Nanopillars

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The ideal surface-enhanced Raman spectroscopy (SERS) substrate should fulfil the following: i) predictable SERS enhancement, ii) macroscale SERS signal uniformity, and iii) suitability for mass production with excellent reproducibility. We have previously shown that SERS-active nanopillar structures (NPs), fabricated by lithography-free processes, show high average SERS enhancements (>10^8) and are mass producible [1-3]. Here we report an improved process and show that these structures exhibit unrivalled macroscale SERS uniformities (RSD: ~2.5% in mm scale, ~7% in inch scale) and SERS reproducibilities (RSD: ~1.5% across three wafers), while at the same time obtaining a very large average enhancement factor of >10^8. We also show a simple example of fast and reliable SERS analysis of low-volume analytes using such structures. We emphasize that the nanofabrication process is cost-effective, and is suitable for mass production in standard IC foundries using even larger silicon wafers.

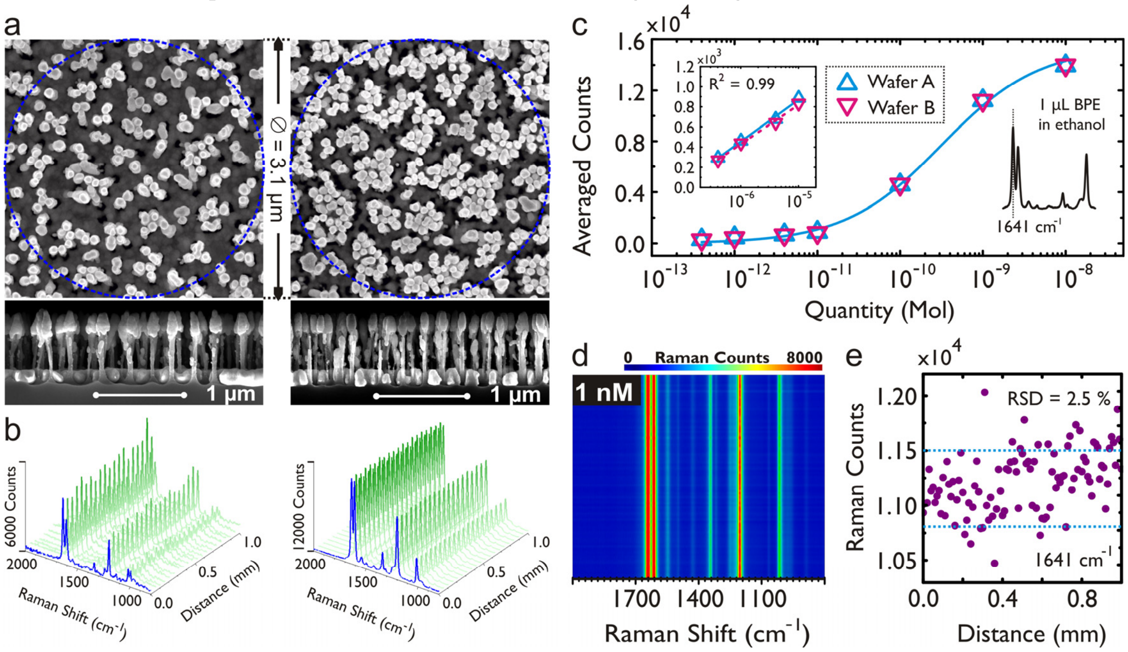

Figure 1. (a) SEM images of the low-density (left) and high-density (right) NPs. The dotted blue circles represent the area of the laser spot for probing SERS signals. (b) The scanned SERS spectra across a 1 mm line of 10^{-9} M BPE on low-density (left) and high-density (right) samples of NPs, corresponding to (a). (c). Quantitative SERS analyses of BPE on two wafers. 100 data points were used for the quantification. (d) Scanned spectra and (e) data points used in (c), for the 10^{-9} M measurement on wafer A.

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